Application Note No. 146

Low Cost 950 - 2150 MHz Direct Broadcast Satellite (DBS) Amplifier with the BFP420F RF Transistor draws 27 mA from 5 V supply

RF & Protection Devices

Never stop thinking

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Revision History: 2008-02-21, Rev. 1.2

Previous Version: 2005-09-19, Rev. 1.1

Page	Subjects (major changes since last revision)
All	Small changes in figure descriptions

1 Low Cost 950 - 2150 MHz Direct Broadcast Satellite (DBS) Amplifier with the BFP420F RF Transistor draws 27 mA from 5 V supply

Overview

- BFP420F RF Transistor in TSFP-4 package is shown in a low-cost DBS IF Amplifier application. Amplifier uses resistive feedback (R2) to achieve stability and broadband matching. Package is 1.4 x 1.2 x 0.55 mm high.
- No chip coils are used to reduce cost; only resistors and capacitors are needed. "0402" size resistors and capacitors are used; total PCB area needed is 45 mm²; total parts count, including the BFP420F transistor, is 9 pieces.
- Printed Circuit Board used is Infineon Part Number 540F-041503 Rev A. Standard FR4 material is used in a two-layer PCB with 0.062 inch / 1.6 mm spacing between RF trace side and ground plane. Please refer to cross-sectional diagram of PCB below.
- The amplifier is unconditionally stable from 5 MHz to 5 GHz; K value dips to 0.88 at 6.5 GHz. See plot of stability factor "K" (**Figure 8**).

Summary of Results

T = 25 °C, Network Analyzer Source Power ≅ -25 dBm, V_{CC} = 5.0 V, I_C = 27.7 mA, Z_S = Z_L = 50 Ω

Table 1 Summary of Results

Frequency MHz	dB [s11]²	dB [s21]²	dB [s12]²	dB [s22]²	NF^* dB	IIP_3 dBm	OIP_3 dBm	IP_{1dB} dBm	OP_{1dB} dBm
950	16.7	17.3	23.0	19.7	2.2	---	---	---	---
1450	19.3	14.6	20.8	23.5	2.3	+8.3	+22.9	-4.5	+9.1
2150	17.4	12.0	17.3	19.3	2.5	---	---	---	---

* PCB loss is not extracted, e.g. reference plane of measurement is at PCB input RF SMA connector. If PCB loss were extracted, noise figure result would improve by 0.1 - 0.2 dB, e.g. NF result would be lower / better.

PCB Cross - Section Diagram

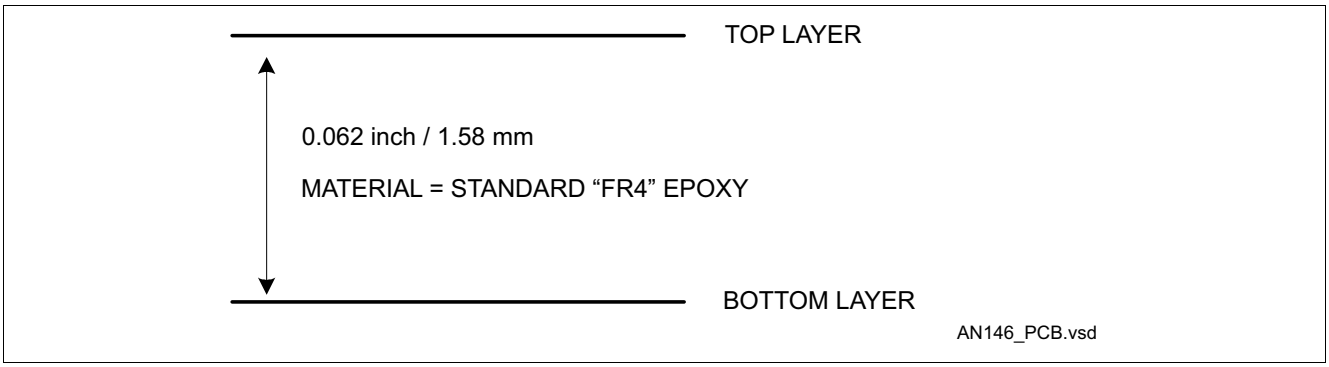


Figure 1 PCB - Cross Sectional Diagram

Schematic Diagram

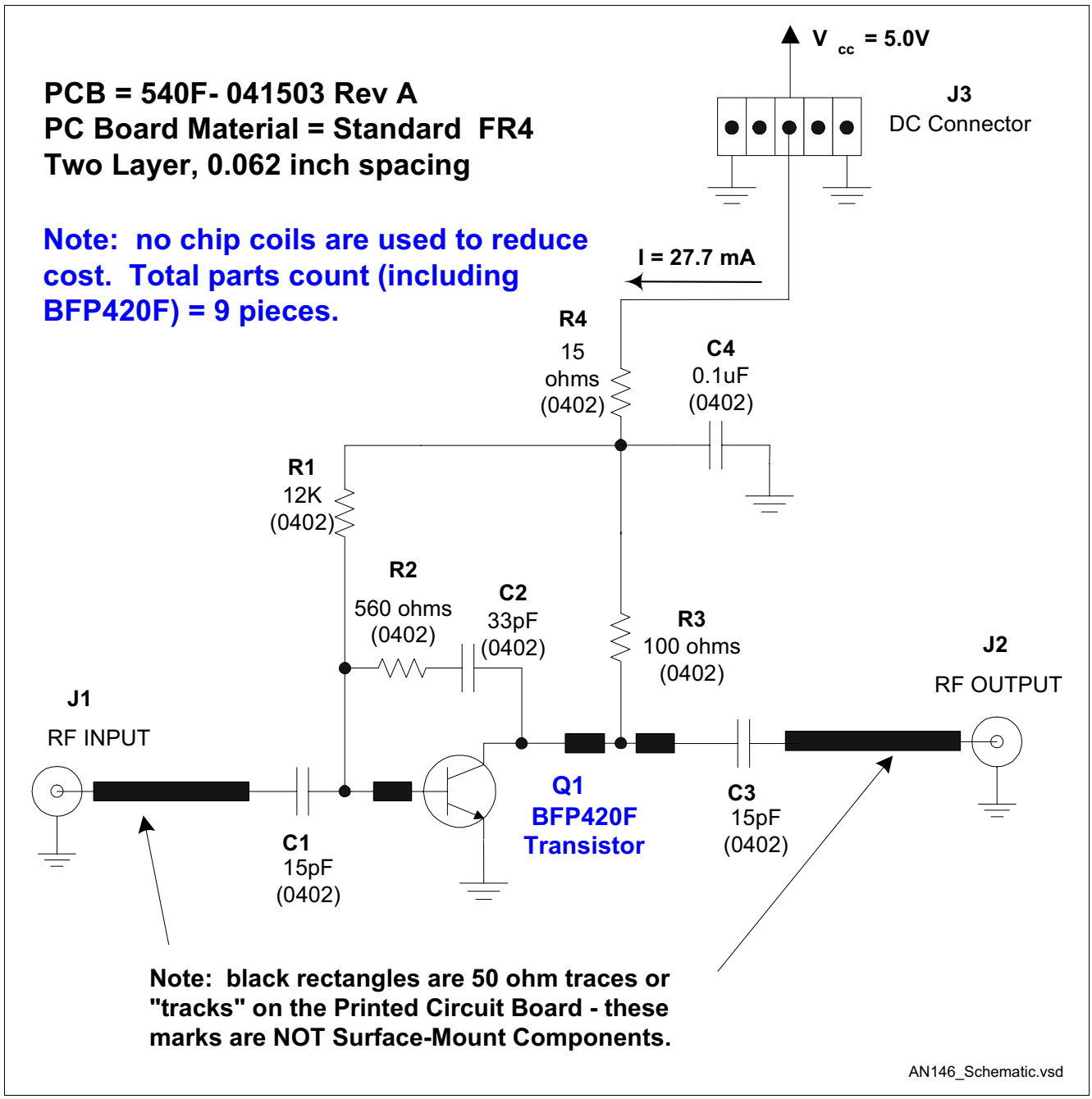


Figure 2 Schematic Diagram

Bill of Material

Table 2 Bill of Material

Reference Designator	Value	Manufacturer	Case Size	Function
C1	15 pF	Various	0402	DC blocking, input.
C2	33 pF	Various	0402	DC block, for RF feedback path.
C3	15 pF	Various	0402	DC block, output.
C4	0.1 µF	Various	0402	Decoupling
R1	12 kΩ	Various	0402	Sets DC bias current.
R2	560 Ω	Various	0402	RF feedback resistor. Feedback broadens matching and helps stabilize amplifier, at cost of reduced gain.
R3	100 Ω	Various	0402	Brings DC to collector of BFP420F, used instead of a coil. Resistor loads output which degrades gain and output 1 dB compression point, but it improves output match, and is lower cost than a chip coil.
R4	15 Ω	Various	0402	DC bias, provides slight negative feedback for DC operation point; helps stabilize collector current over variations in device DC current gain, over temperature, etc.
Q1	-	Infineon Technologies	TSFP-4	BFP420F B6HF Low Noise RF Transistor
J1, J2	-	Johnson 142-0701-841	-	RF input / output connectors
J3	-	AMP 5 pin header MTA-100 series 640456-5 (standard pin plating) or 641215-5 (gold plated pins)	-	DC connector Pins 1, 5 = ground Pin 3 = V_{CC} Pins 2, 4 = no connection

TSFP-4 Package Details

(Dimensions in Millimeters). Note maximum package height is 0.59 mm / 0.023 inch.

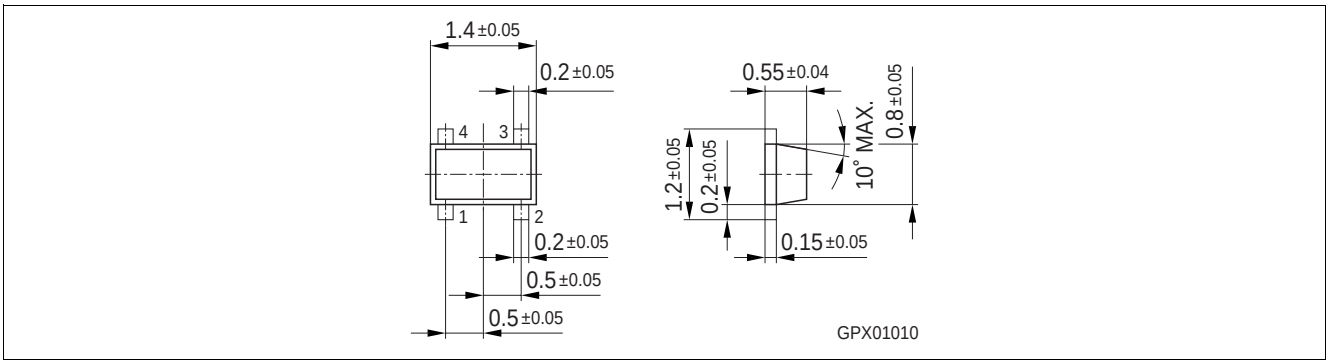


Figure 3 Package Details of TSFP-4

Recommended Soldering Footprint for TSFP-4 (dimensions in millimeters).

Device package is to be oriented as shown in above drawing (e.g. orient long package dimension horizontally on this footprint).

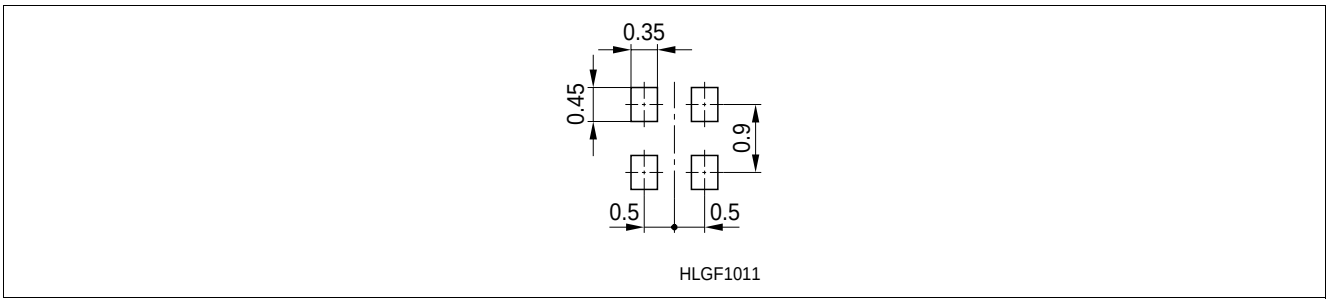


Figure 4 Package Footprint of TSFP-4

Noise Figure, Plot, Center of Plot (x-axis) is 1575 MHz.

Rohde & Schwarz FSEK3

19 Sep 2005

Noise Figure

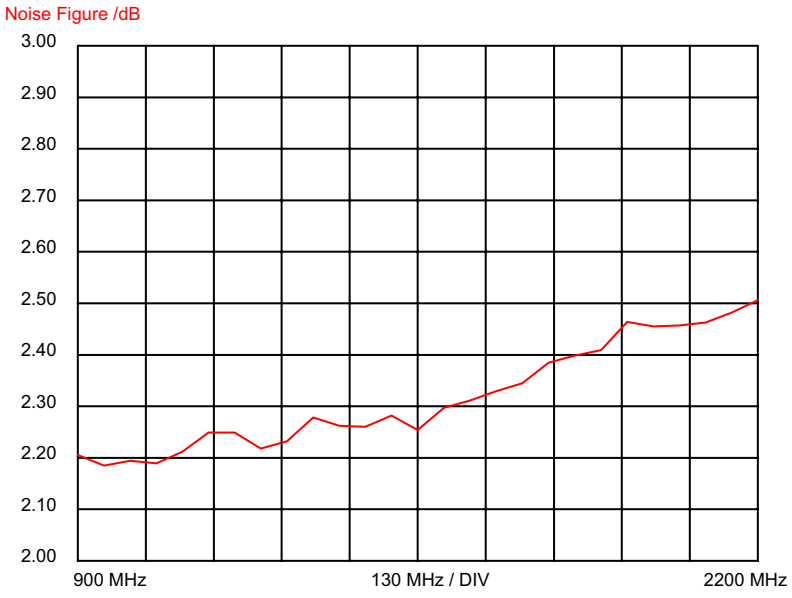
EUT Name:	BFP420F DBS Amplifier
Manufacturer:	Infineon Technologies
Operating Conditions:	V=5.0 V, I=27.7mA, T=25 C
Operator Name:	Gerard Wevers
Test Specification:	LWR SD 00091 LNA P
Comment:	on PCB 540F-041503 Rev A 19 Sept 2005

Analyzer

RF Att:	0.00 dB	RBW :	1 MHz	Range:	40.00 dB
Ref Lvl:	-41.00 dBm	VBW :	100 Hz	Ref Lvl auto:	ON

Measurement

2nd stage corr: ON	Mode: Direct	ENR: HP346A.ENR



AN146_plot_nf.vsd

Figure 5 Noise Figure

Noise Figure, Tabular Data

From Rohde & Schwarz FSEK3 + FSEM30 + System Preamplifier
System Preamplifier = MITEQ SMC-02

Table 3 Noise Figure

Frequency	Noise Figure
900 MHz	2.21 dB
950 MHz	2.18 dB
1000 MHz	2.19 dB
1050 MHz	2.19 dB
1100 MHz	2.21 dB
1150 MHz	2.25 dB
1200 MHz	2.25 dB
1250 MHz	2.22 dB
1300 MHz	2.23 dB
1350 MHz	2.28 dB
1400 MHz	2.26 dB
1450 MHz	2.26 dB
1500 MHz	2.28 dB
1550 MHz	2.25 dB
1600 MHz	2.30 dB
1650 MHz	2.31 dB
1700 MHz	2.33 dB
1750 MHz	2.34 dB
1800 MHz	2.39 dB
1850 MHz	2.40 dB
1900 MHz	2.41 dB
1950 MHz	2.46 dB
2000 MHz	2.45 dB
2050 MHz	2.46 dB
2100 MHz	2.46 dB
2150 MHz	2.48 dB
2200 MHz	2.51 dB

Scanned Image of PC Board

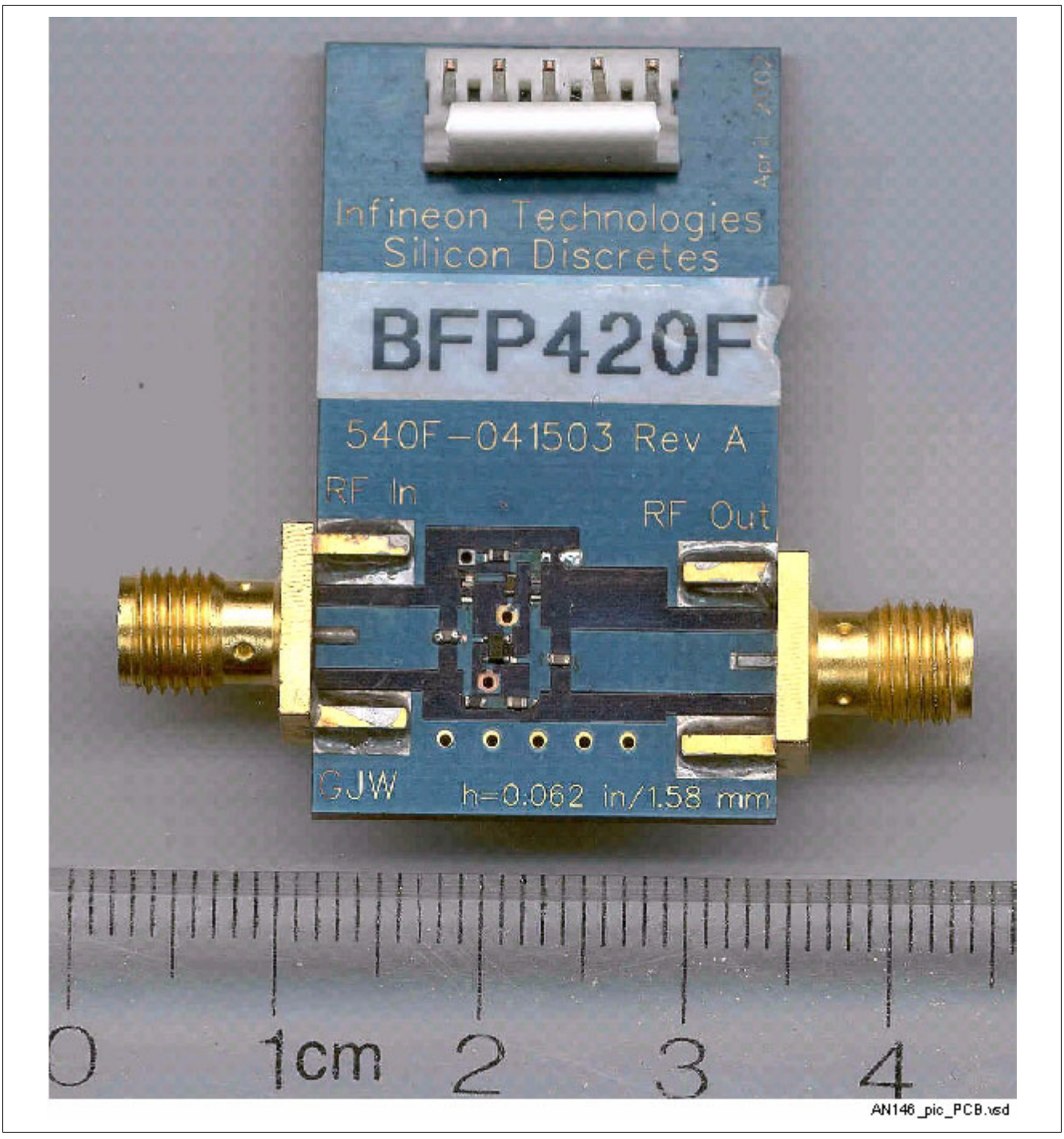


Figure 6 Image of PC Board

Scanned Image of PC Board, Close-In Shot.

Total PCB area used is approximately 45 mm².

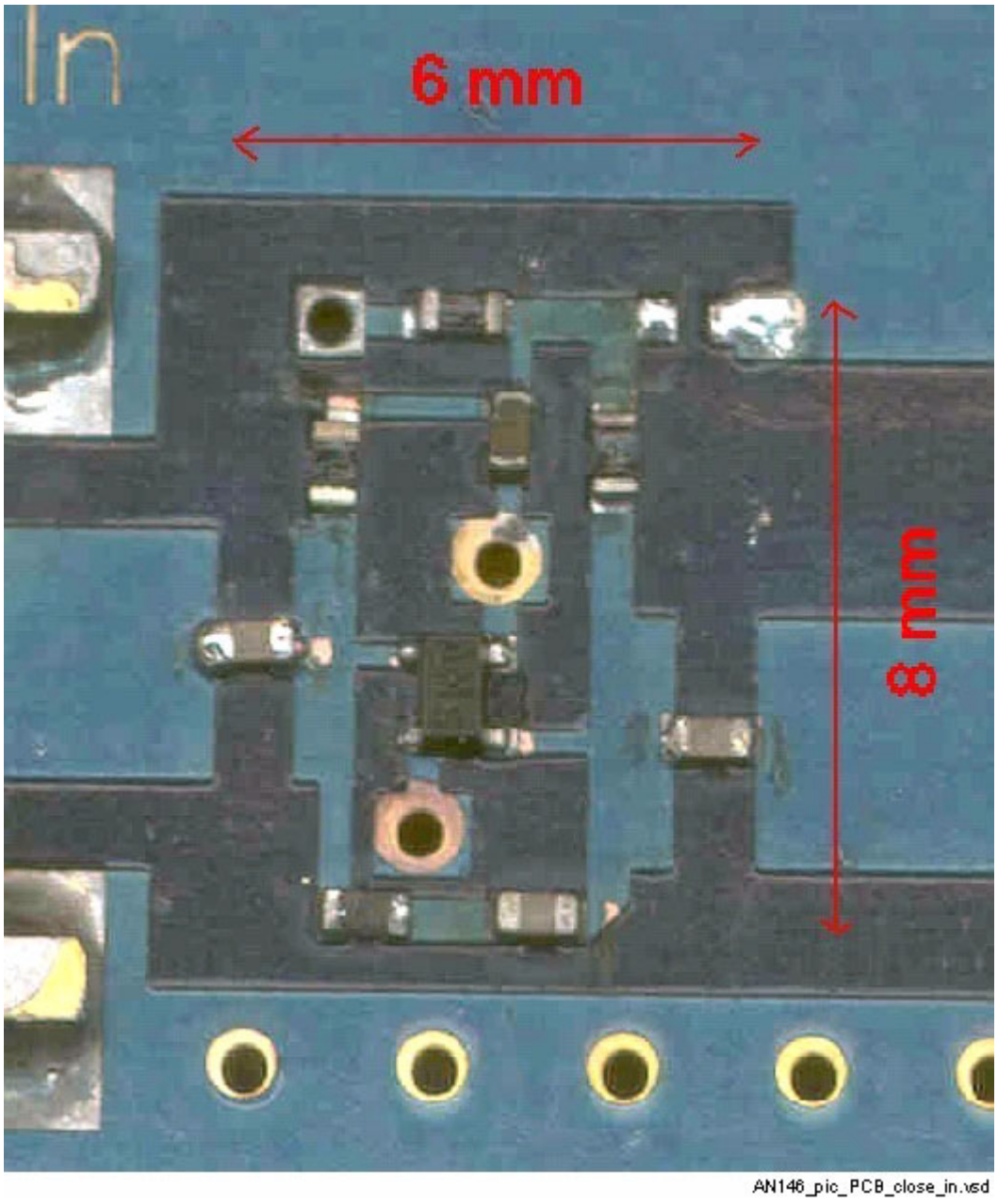


Figure 7 Image of PC Board, Close-In Shot

Amplifier Stability

T = 25 °C, V_{CC} = 1.8 V, V_{CE} = 1.9 V, I = 27.7 mA

Stabilty Factor "K" is shown below from "screen shot" taken from Rohde and Schwarz ZVC network analyzer. ZVC Vector Network Analyzer calculates and plots K in real time, from measured S parameters. Note that K > 1 up to 5 GHz, with minimum K value is 0.89 at 6.5 GHz; the amplifier is unconditionally stable over 5 MHz to 5 GHz range, and conditionally stable for 5 GHz < f < 7 GHz.

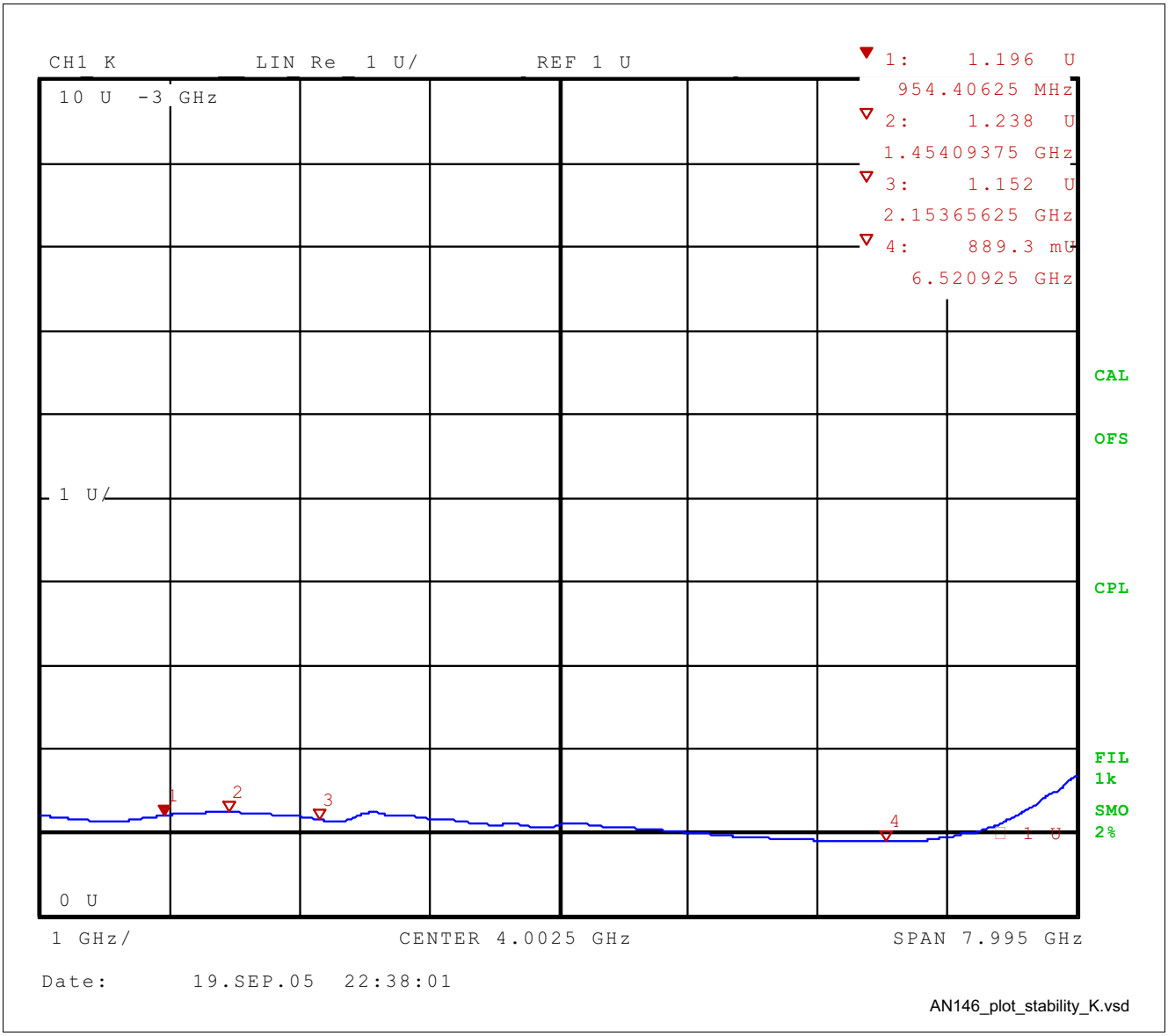


Figure 8 Plot of K(f)

Gain Compression at 1450 MHz

T = 25 °C, V_{CC} = 5.0 V, V_{CE} = 1.9 V, I = 27.7 mA

Amplifier is checked for 1 dB compression point. An Agilent power meter was used to ensure accurate power levels are measured (as opposed to using Vector Network Analyzer in "Power Sweep" mode).

Output P_{1dB} ≅ +9.1 dBm; Input P_{1dB} ≅ +9.1 dBm - (Gain - 1 dB) = +9.1 dBm - 13.6 dB = -4.5 dBm

Table 4 Gain Compression

P_{OUT}, dBm	Gain, dB
-4.0	14.6
-3.0	14.6
-2.0	14.6
-1.0	14.6
0.0	14.6
+1.0	14.5
+2.0	14.5
+3.0	14.5
+4.0	14.5
+5.0	14.4
+6.0	14.4
+7.0	14.3
+8.0	14.1
+9.0	13.7
+10.0	12.1

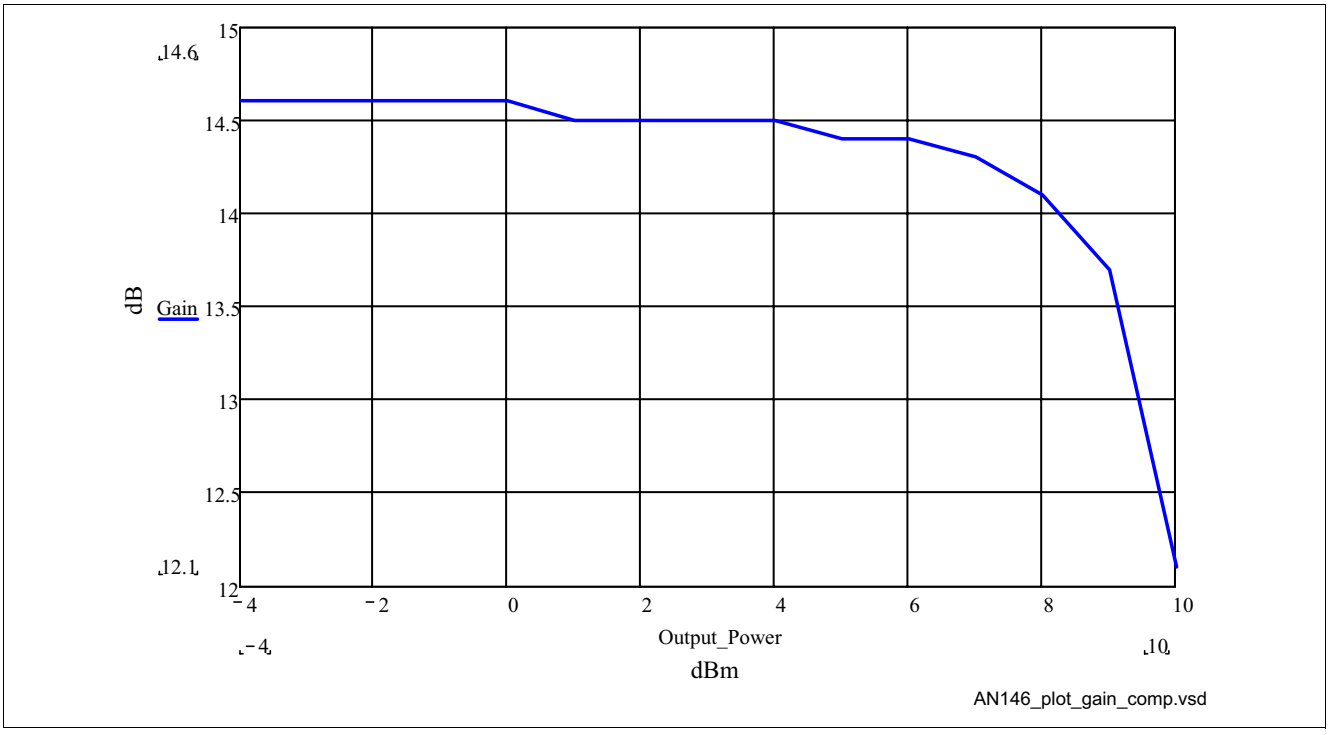


Figure 9 Plot of BFP420F Gain Compression, 1450 MHz

Please Note - all plots are taken from ZVC Network Analyzer, T = 25 °C, source power ≈ -25 dBm.

Input Return Loss, Log Mag

5 MHz - 8 GHz Sweep

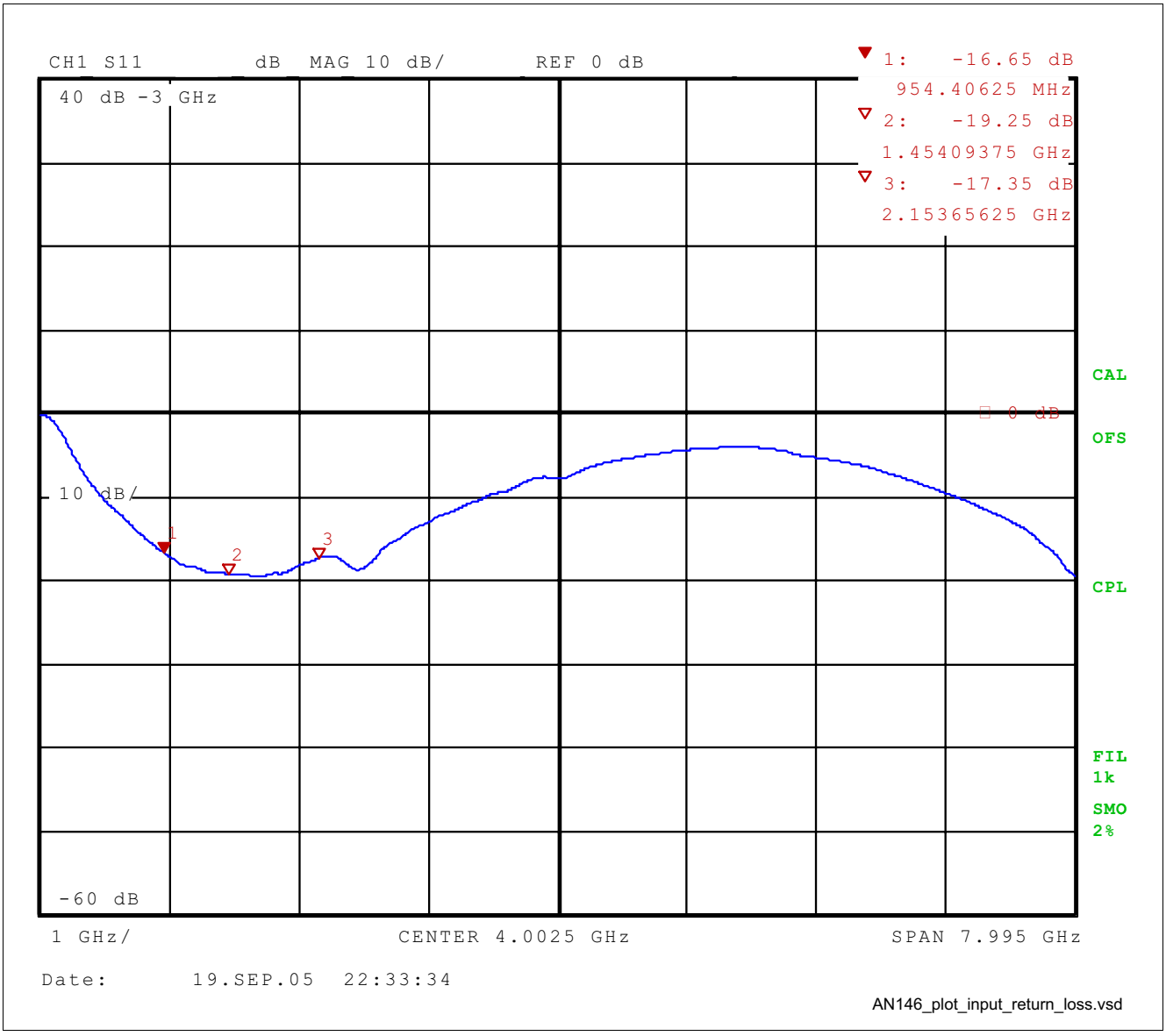


Figure 10 Plot of Input Return Loss

Input Return Loss, Smith Chart

Reference Plane = Input SMA Connector on PC Board
5 MHz - 8 GHz Sweep

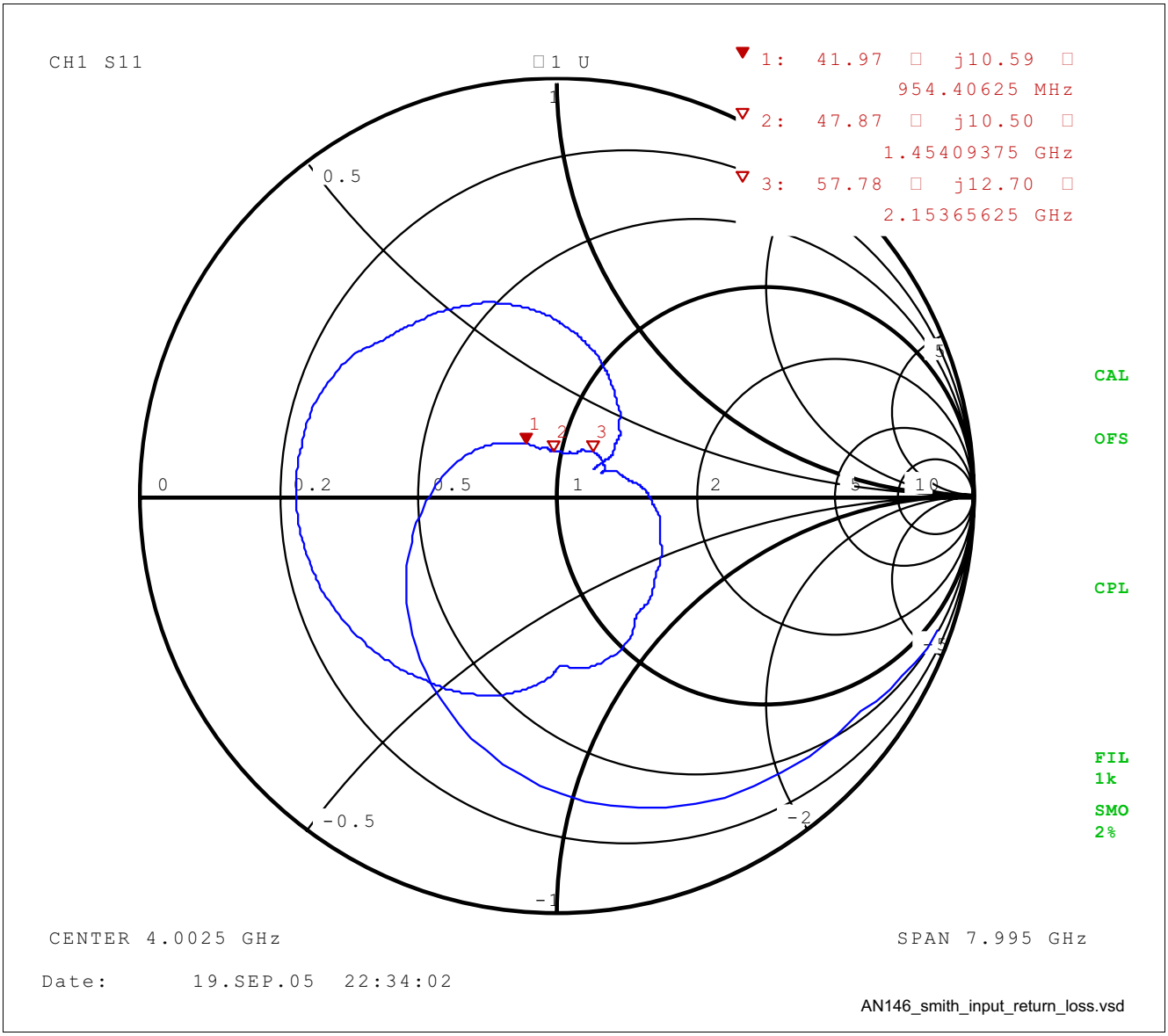


Figure 11 Smith Chart of Input Return Loss

Forward Gain

5 MHz - 8 GHz Sweep

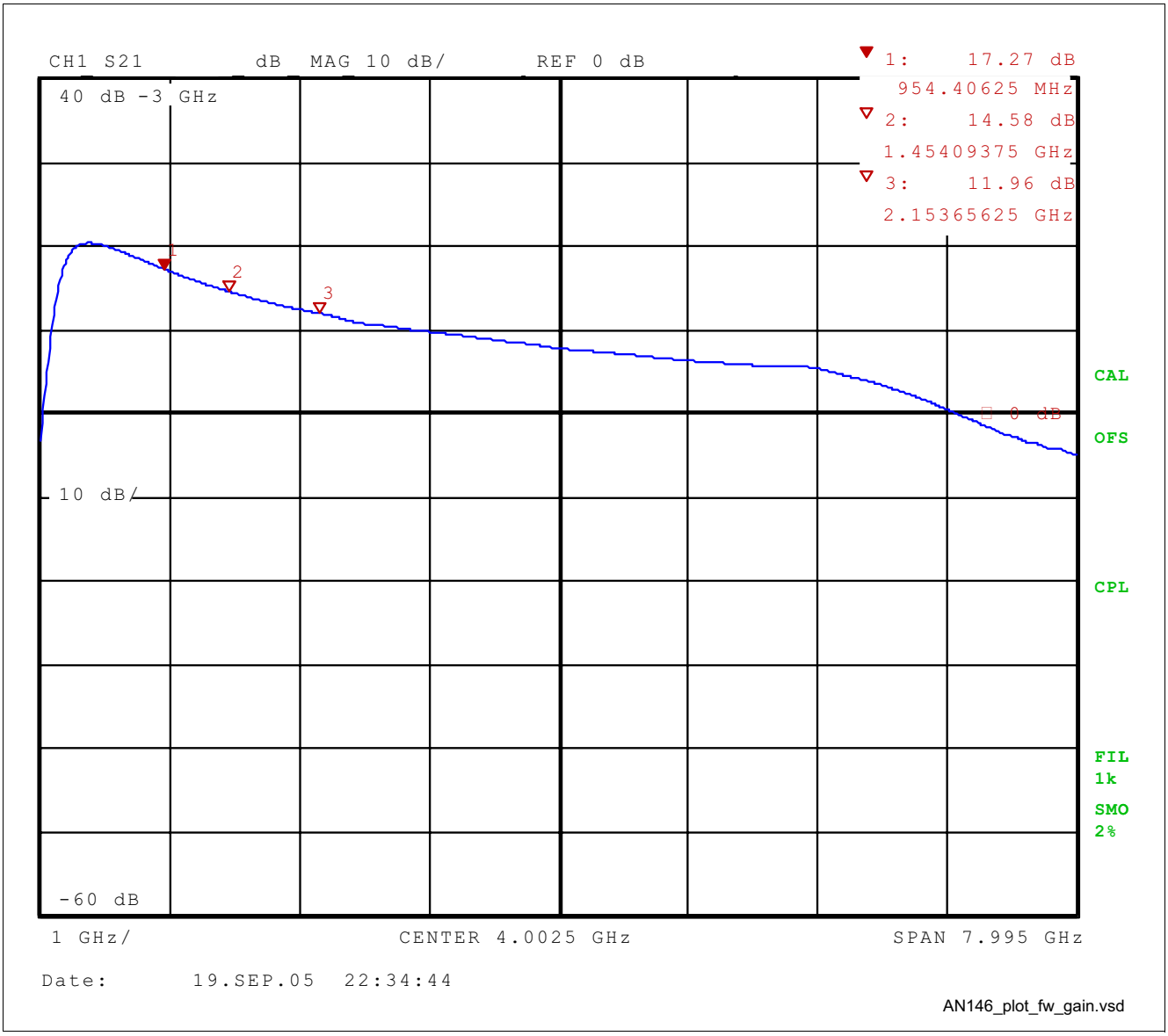


Figure 12 Plot of Forward Gain

Reverse Isolation

5 MHz - 8 GHz

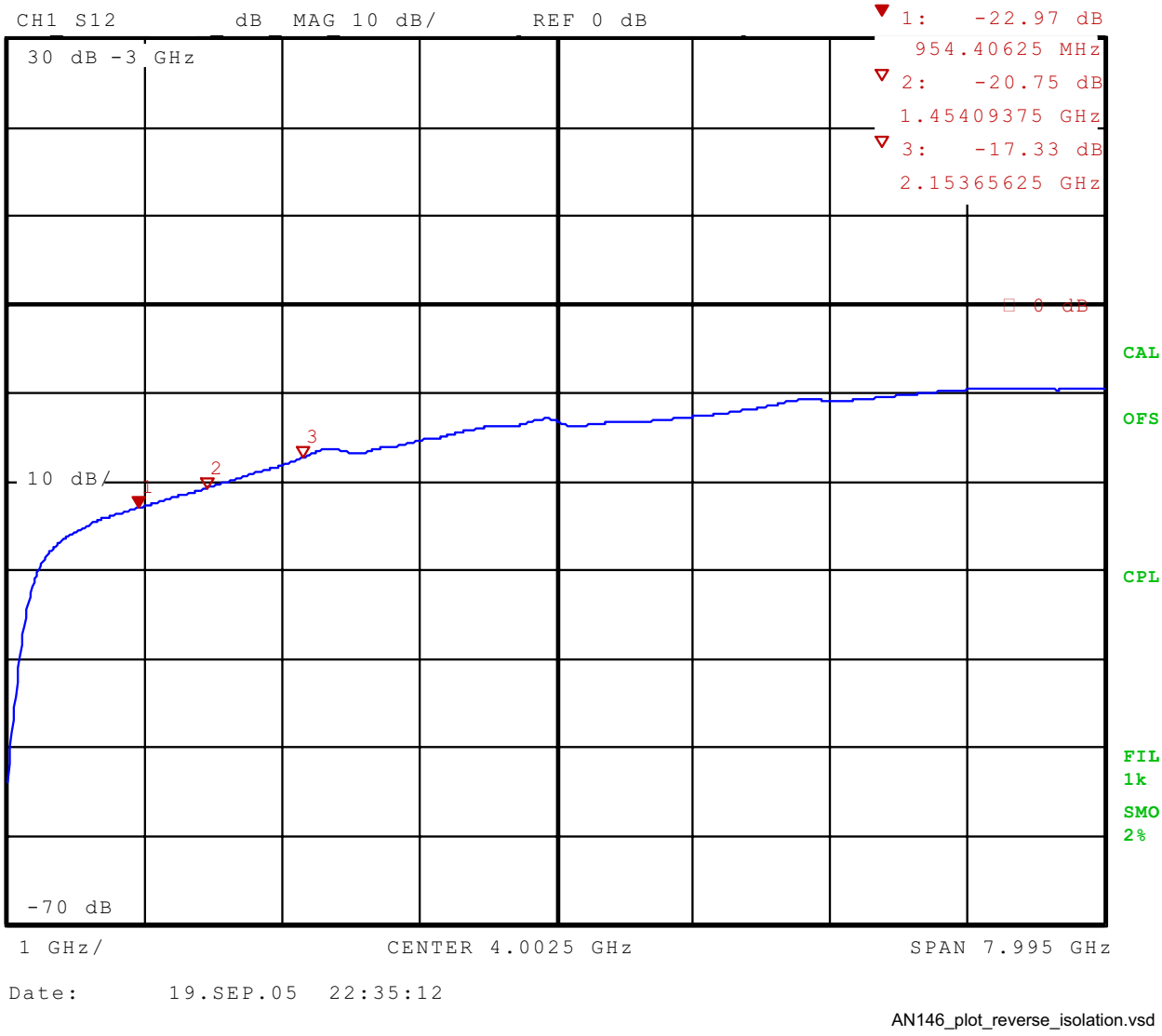


Figure 13 Plot of Reverse Isolation

Output Return Loss, Log Mag

5 MHz - 8 GHz

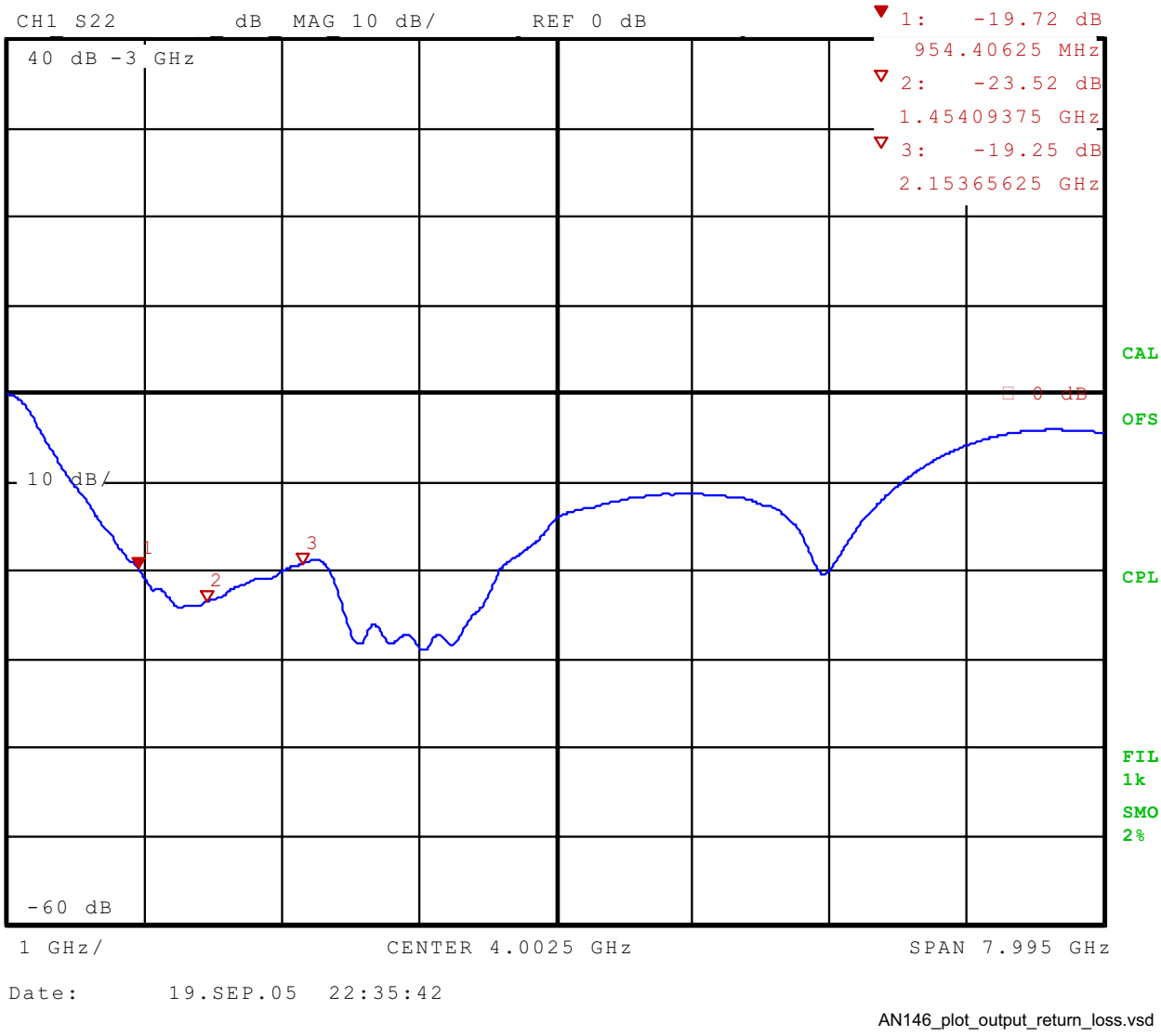


Figure 14 Plot of Output Return Loss

Output Return Loss, Smith Chart

Reference Plane = Output SMA Connector on PC Board
5 MHz - 8 GHz Sweep

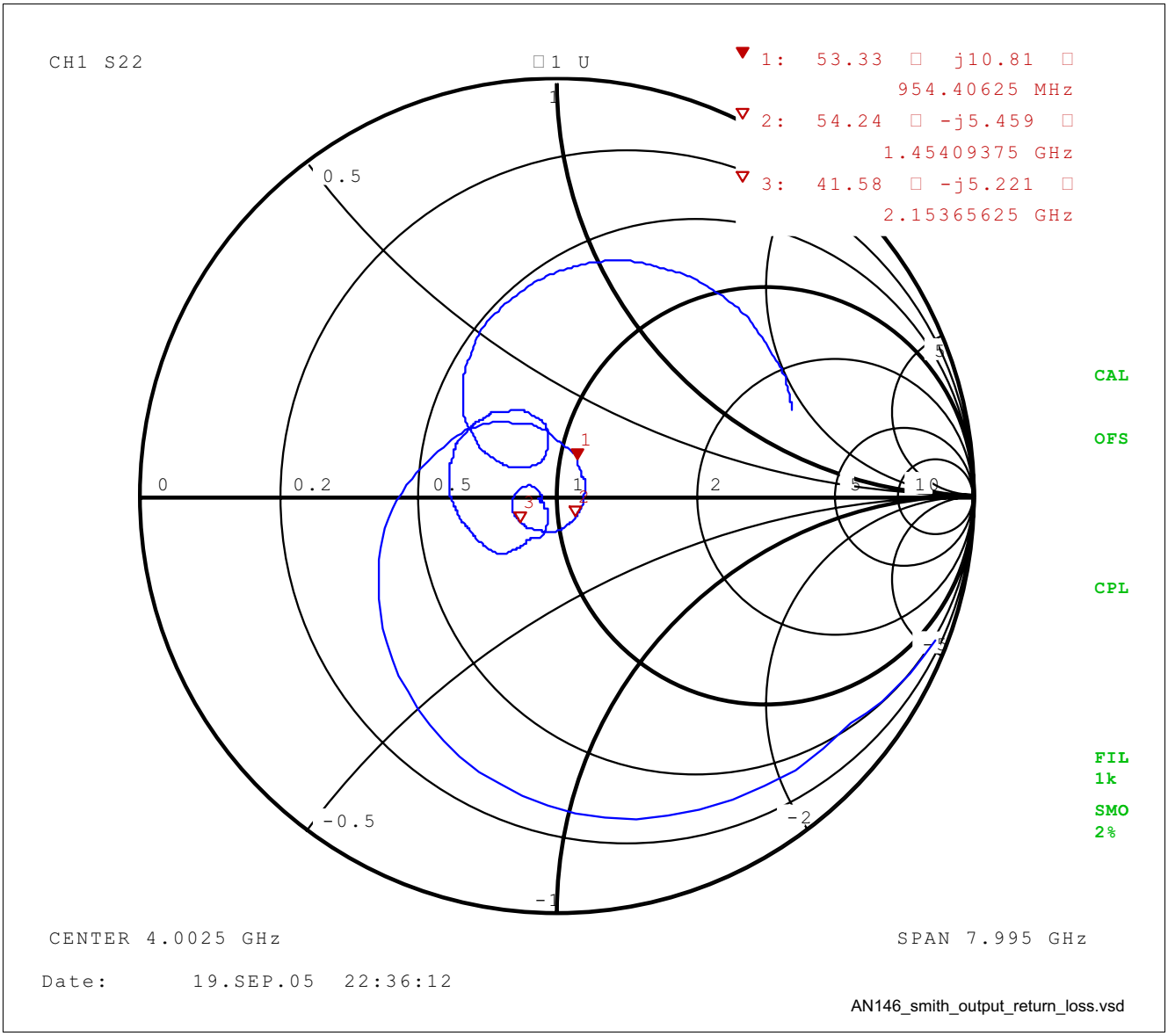


Figure 15 Smith Chart of Output Return Loss

Amplifier response to Two Tone Test

Input stimulus: f_1 = 1450 MHz, f_2 = 1451 MHz, -20 dBm each tone.

Input IP_3 = -20 + (56.6 / 2) = +8.3 dBm

Output IP_3 = +8.3 dBm + 14.6 dB gain = +22.9 dBm

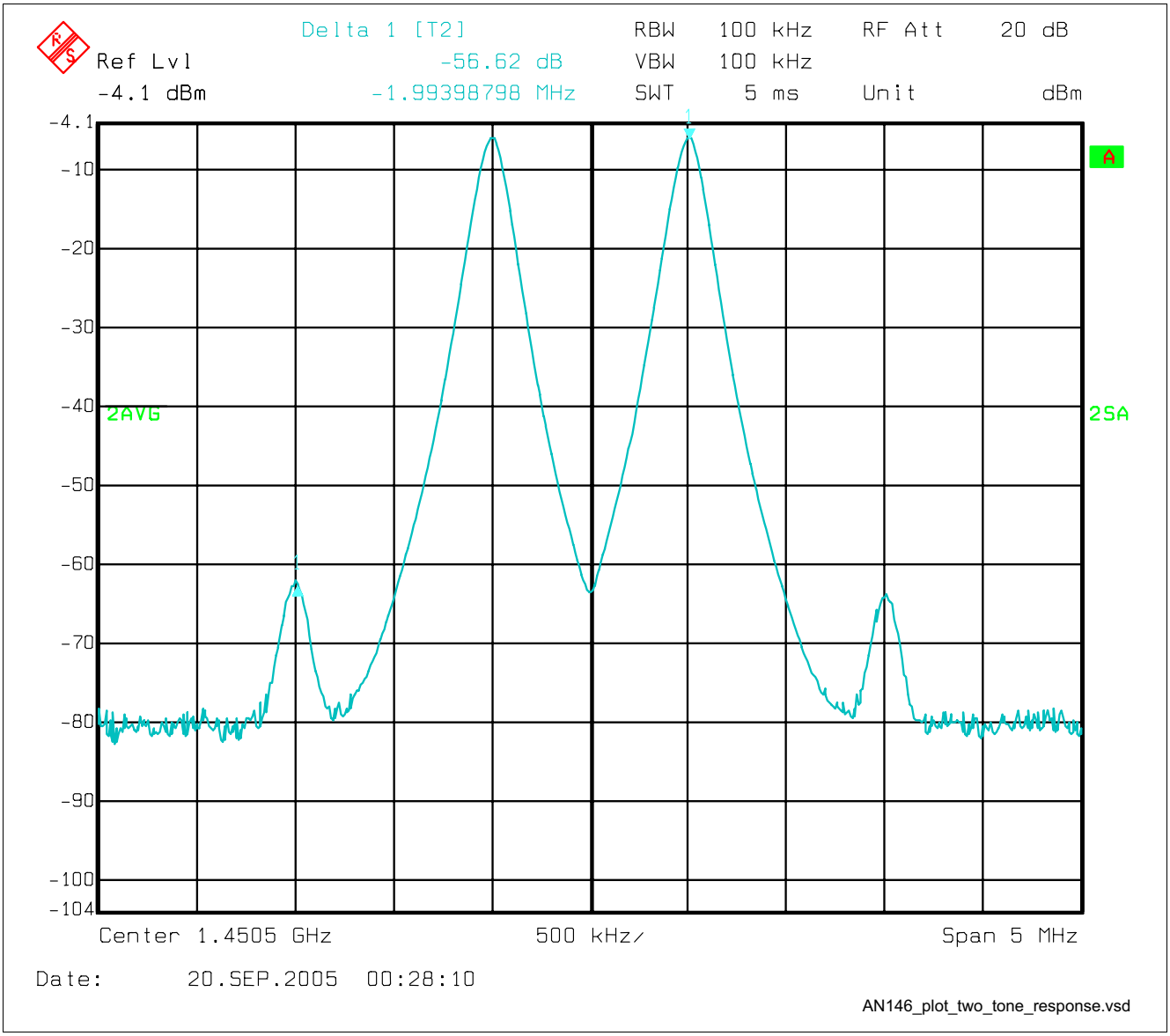


Figure 16 Tow-Tone Test, LNA Response